Space Technology Research Grants

Quantifying the Value of Resilience in Long-Duration Space Systems

Completed Technology Project (2014 - 2018)

Project Introduction

This research will develop tools and methods to enable engineers to quantify the costs and benefits of system resilience during the early phases of the design process for long-duration space systems (both human and robotic). Specifically, system requirements will be mapped to processes that must be accomplished by the system, as well as objects that handle those processes. This object-process model of the system will be used to create a Markov model made up of all possible states of the system, where each state is characterized by the identification of which components (or objects) within the system are not functional. As components fail, the processes they handle cease to be accomplished, and the requirements mapped to those processes are no longer fulfilled. Analysis of this Markov model yields the probability of the system being in a given state at a given time; therefore this technique enables the determination of the probability for each system requirement that the system will be able to meet that requirement at a given point in the mission timeline. Since a system's benefit is derived from its ability to meet its requirements, this methodology provides a quantitative and objective metric that is directly related to the value of a system. This metric, and the methodology that computes it, will facilitate system trades with respect to the level of resilience and enable the use of formal multidisciplinary design optimization techniques during concept selection and early-phase design. In this way, this research will assist space system designers in the creation of more capable and cost-effective systems in order to meet the challenges of future long-duration spaceflight.

Anticipated Benefits

This metric, and the methodology that computes it, will facilitate system trades with respect to the level of resilience and enable the use of formal multidisciplinary design optimization techniques during concept selection and early-phase design. In this way, this research will assist space system designers in the creation of more capable and cost-effective systems in order to meet the challenges of future long-duration spaceflight.

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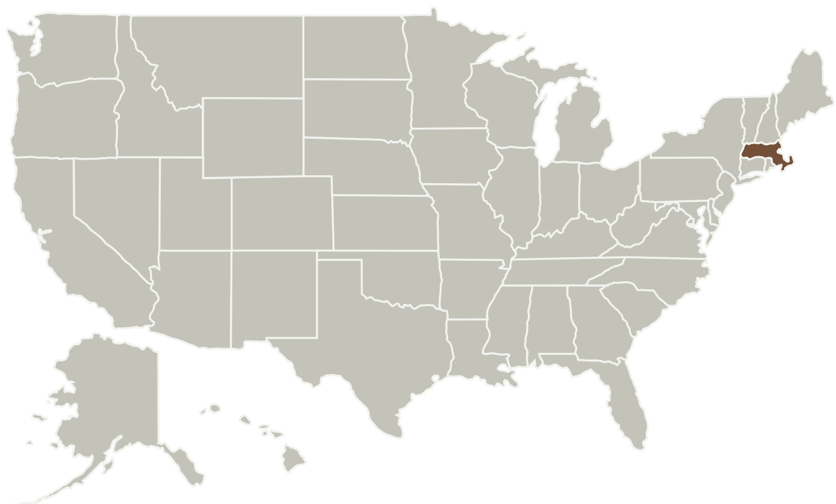
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations
Massachusetts

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

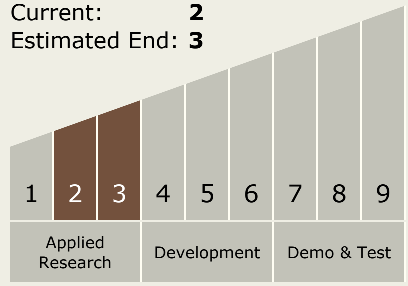
Olivier De Weck

Co-Investigator:

Andrew D Owens

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - └ TX11.5 Mission Architecture, Systems Analysis and Concept Development
    - └ TX11.5.2 Tools and Methodologies for Performing Systems Analysis

Target Destination

Foundational Knowledge